

The invention in which an exclusive right is claimed is defined by the following:

1. A contactless electrical energy transfer apparatus comprising:

(a) a portable receiving unit including:

(i) a receiver coil; and

(ii) a housing in which the receiver coil is disposed, said housing supporting the receiver coil and extending outwardly from a main body of said portable receiving unit, such that said housing and receiver coil are substantially separated from said main body; and

(b) a flux generator including:

(i) a base adapted to be disposed proximate to the receiving unit, said base comprising a cradle section and a charging section, said charging section being adapted to receive said housing in which the receiver coil is disposed;

(ii) a magnetic field generator comprising at least one permanent magnet disposed within the base; and

(iii) a prime mover drivingly coupled to an element of the magnetic field generator, causing said element of the magnetic field generator to move relative to the receiver coil, movement of said element of the magnetic field generator producing a varying magnetic field that is coupled to the receiver coil, inducing an electrical current to flow in the receiver coil.

2. The energy transfer apparatus of Claim 1, wherein said cradle portion has a size and shape generally corresponding to said main body.

3. The energy transfer apparatus of Claim 1, wherein said charging portion includes a receptacle having a size and shape generally corresponding to said housing of the receiver coil.

4. The energy transfer apparatus of Claim 1, wherein said charging portion includes gripping means for retaining said housing in a desired position.

5. The energy transfer apparatus of Claim 4, wherein said gripping means comprises an elastomeric material.

6. The energy transfer apparatus of Claim 1, further comprising a plurality of cradle portions and a plurality of charging portions.

7. The energy transfer apparatus of Claim 6, wherein each cradle portion is associated with a different charging portion.

8. The energy transfer apparatus of Claim 7, wherein each charging portion is disposed about a central axis of an associated cradle portion.

9. The energy transfer apparatus of Claim 7, wherein each charging portion is offset from a central axis of an associated cradle portion.

10. The energy transfer apparatus of Claim 6, wherein each cradle portion is associated with a plurality of charging portions.

11. The energy transfer apparatus of Claim 6, wherein said plurality of cradle portions are disposed adjacent to a periphery of said base, and said plurality of charging portions are disposed adjacent to a central core of said base.

12. The energy transfer apparatus of Claim 6, wherein said magnetic field generator directs a magnetic flux generally toward a central core of said base and away from a periphery of said base.

13. The energy transfer apparatus of Claim 6, wherein at least one cradle portion is substantially larger in size than said portable receiving unit, such that a different portable receiving unit, having a different size and shape than said portable receiving unit, can be accommodated by said at least one cradle portion.

14. The energy transfer apparatus of Claim 1, wherein said housing and said receiver coil are substantially flexible, enabling said housing and said receiver coil to be substantially flexed when received into said charging portion.

15. The energy transfer apparatus of Claim 1, wherein said housing comprises an antenna.

16. The energy transfer apparatus of Claim 15, wherein said receiver coil is also adapted for receiving radio frequency signals.

17. The energy transfer apparatus of Claim 1, further comprising a rechargeable battery disposed within the main body of said portable receiving unit, said receiver coil being electrically coupled to recharge the rechargeable battery.

18. The energy transfer apparatus of Claim 1, wherein said varying magnetic field produced by said magnetic field generator magnetic field generator is substantially weaker at said main body than at said receiver coil.

19. The energy transfer apparatus of Claim 1, wherein the prime mover is disposed within the base of the flux generator.

20. The energy transfer apparatus of Claim 1, wherein the prime mover comprises an electric motor.

21. The energy transfer apparatus of Claim 1, wherein the prime mover is disposed outside the housing of the magnetic field generator and is drivingly coupled to said element of the magnetic field generator through a driven shaft.

22. The energy transfer apparatus of Claim 1, wherein said at least one permanent magnet is moved by the prime mover.

23. The energy transfer apparatus of Claim 1, wherein said at least one permanent magnet comprises a rare earth alloy.

24. The energy transfer apparatus of Claim 1, wherein the magnetic field generator includes a plurality of permanent magnets and a support on which the plurality of permanent magnets are mounted, said prime mover causing the support to move, thereby varying the magnetic field along a path that includes the receiver coil.

25. The energy transfer apparatus of Claim 24, wherein the support is caused to move reciprocally back and forth in a reciprocating motion.

26. The energy transfer apparatus of Claim 1, wherein the element of the magnetic field generator that is drivingly coupled to the prime mover comprises a magnetic flux shunt that is moved by the prime mover, to periodically shunt a magnetic field produced by said at least one permanent magnet of the magnetic field generator, causing the magnetic field to vary along a path that includes the receiver coil.

27. The energy transfer apparatus of Claim 1, further comprising an adjustment member that is selectively actuatable to change a maximum magnetic flux that is coupled to the receiver coil.

28. The energy transfer apparatus of Claim 27, wherein the adjustment member controls a speed with which the element of the magnetic field generator is moved.

29. The energy transfer apparatus of Claim 1, wherein the magnetic field generator includes a plurality of permanent magnets mounted to the element at radially spaced-apart points around a central axis, enabling the varying magnetic field produced by magnetic field generator to couple with a plurality of different size receiver coils.

30. The energy transfer apparatus of Claim 29, wherein the prime mover rotates the element and the plurality of permanent magnets about the central axis.

31. A contactless electrical energy transfer apparatus adapted to couple magnetic energy into a portable device having a main body and a magnetic energy receiving portion, comprising:

(a) a base adapted to be disposed proximate to the magnetic energy receiving portion, said base comprising a cradle section and a charging section, said cradle section being adapted to support said main body, and said charging section being adapted to receive said magnetic energy receiving portion of the portable device;

(b) a prime mover; and

(c) a magnetic field generator that is disposed within the base, said magnetic field generator comprising a permanent magnet and including an element that is moved by the prime mover, causing a varying magnetic field to be produced for coupling with the magnetic energy receiving portion of the portable device, the varying magnetic field being substantially excluded from the main body portion of the portable device.

32. The energy transfer apparatus of Claim 31, wherein said cradle section has a size and shape generally corresponding to that of said main body portion.

33. The energy transfer apparatus of Claim 31, wherein said charging section has a slot with a size and shape generally corresponding to that of said magnetic energy receiving portion.

34. The energy transfer apparatus of Claim 31, wherein said charging section is of a size sufficient to provide an interference fit that retains said magnetic energy receiving portion in a desired position.

35. The energy transfer apparatus of Claim 34, wherein said charging section comprises elastomeric gripping means for providing the interference fit.

36. The energy transfer apparatus of Claim 31, further comprising a plurality of cradle sections and a plurality of charging sections.

37. The energy transfer apparatus of Claim 36, wherein each cradle section is associated with a different charging section.

38. The energy transfer apparatus of Claim 37, wherein each charging section is disposed in alignment with a central axis of an associated cradle section.

39. The energy transfer apparatus of Claim 37, wherein each charging section is offset from a central axis of an associated cradle section.

40. The energy transfer apparatus of Claim 36, wherein each cradle section is associated with a plurality of charging section.

41. The energy transfer apparatus of Claim 36, wherein said plurality of cradle sections are disposed adjacent to a periphery of said base, and said plurality of charging sections are disposed adjacent to a central core of said base.

42. The energy transfer apparatus of Claim 36, wherein said magnetic field generator directs a magnetic flux substantially toward a central core of said base, and away from a periphery of said base.

43. The energy transfer apparatus of Claim 36, wherein at least one cradle portion is substantially larger in size than said portable device, such that a different portable device, having a different size and shape than said portable device, can be accommodated by said at least one cradle portion.

44. Contactless electrical energy transfer apparatus comprising:

(a) a portable device that includes:

(i) a receiver coil disposed in a receiver housing; and

(ii) a main housing in which electronic components of the portable device are disposed, said receiver housing extending outwardly from said main housing such that said receiver housing and receiver coil are substantially distinct from said main housing; and

(b) a flux generator including:

(i) a base adapted to be disposed proximate to the portable device, said base comprising a cradle section and a charging section, said cradle section receiving said main housing and said charging section receiving said receiver housing when the portable device is receiving energy;

(ii) a magnetic field generator disposed within the base for the flux generator and comprising at least one permanent magnet and a flux shunt, said at least one permanent magnet being fixed relative to the receiver coil; and

(iii) a prime mover that is drivingly coupled to said flux shunt, said flux shunt being moved by the prime mover, to intermittently pass adjacent to pole faces of said at least one permanent magnet so as to provide a magnetic flux shunt path between the pole faces, thereby varying a magnetic field experienced by the receiver coil, inducing an electrical current to flow in the receiver coil, said varying magnetic field being generally directed away from said main housing.

45. The energy transfer apparatus of Claim 48, wherein said charging section comprises means for gripping said receiver coil.

46. The energy transfer apparatus of Claim 48, further comprising a plurality of cradle sections and a plurality of charging sections, each cradle section being associated with at least one charging section, said plurality of charging sections being disposed adjacent a central core of said base.

47. A contactless electrical energy transfer apparatus that supplies electrical energy to a portable device, where the portable device includes a receiver coil attached to a main housing, comprising:

- (a) a charging base that is adapted to be disposed proximate to the portable device, said charging base having a charging section and being adapted to support the portable device with said charging section positioned proximate to the receiver coil of the portable device;
- (b) a magnetic field generator disposed within the charging base, said magnetic field generator including a permanent magnet having opposite pole faces, and a flux shunt that is movably supported within the charging base;
- (c) a prime mover that is drivingly coupled to the flux shunt, causing the flux shunt to move and intermittently pass adjacent to the opposite pole faces of said permanent magnet so as to provide a magnetic flux shunt path between the pole faces, thereby producing a varying magnetic field that is coupled with the receiver coil of the portable device, the varying magnetic field inducing an electrical current to flow in the receiving coil for use in energizing the portable device, said charging base being configured to direct the varying magnetic field toward the receiver coil of the portable device, and away from the main housing of the portable device.

48. The energy transfer apparatus of Claim 51, wherein the flux shunt comprises a bar of magnetically permeable material that extends over the opposite pole faces of the permanent magnet in at least one orientation, as the flux shunt is moved by the prime mover.

49. The energy transfer apparatus of Claim 51, wherein the magnetic field generator includes a plurality of permanent magnets, and a fixed flux linkage bar coupling magnetic flux between different pole faces of the plurality of permanent magnets, said flux shunt periodically being moved over opposite pole faces of the plurality of permanent magnets to produce the varying magnetic field.

50. A contactless battery charging and energy transfer apparatus, comprising:

(a) a flux generating base unit that includes:

(i) an electric motor having a drive shaft;

(ii) magnetic structure, operatively coupled to the drive shaft of the electric motor and drivingly rotated thereby, said magnetic structure a plurality of permanent magnets, each permanent magnet having a north pole face and a south pole face oriented generally parallel to a rotational plane of the magnetic structure; and

(iii) a housing in which the electric motor and magnetic structure are disposed, a surface of the housing defining a contactless mounting interface;

(b) a receiving unit that includes:

(i) an electrical energy-consuming load;

(ii) a main housing in which said electrical energy-consuming load is disposed; and

(iii) a receiver coil having a core formed of a magnetically permeable material and an electrically conductive winding wound around the core, said receiver coil being adapted to be placed proximate the contactless mounting interface, said receiver coil extending outwardly and away from said main housing, such that a varying magnetic field produced by the flux generating base unit and directed toward said receiver coil is generally not experienced by the main housing of the receiving unit, thereby preventing said electrical energy-consuming load from being affected by the varying magnetic field; and

(c) a conditioning circuit electrically connected to the winding of the receiver coil, wherein a rotation of the magnetic structure by the electric motor causes the receiver coil to experience a varying magnetic field, inducing an electrical current to flow in said winding, said electrical current being conditioned by the conditioning circuit for use in supplying electrical energy to the load.

51. The contactless battery charging and energy transfer apparatus of Claim 50, wherein the load in the receiving unit comprises a rechargeable storage battery.

52. The contactless battery charging and energy transfer apparatus of Claim 50, wherein the receiving coil and the contactless mounting interface of the flux generator base unit are elongate in shape.

53. The contactless battery charging and energy transfer apparatus of Claim 51, further comprising a sensor that produces a signal indicative of whether the receiving coil is properly mated with the contactless mounting interface of the flux generating base unit.

54. The contactless battery charging and energy transfer apparatus of Claim 53, wherein the sensor comprises one of a Hall-effect sensor and a reed switch disposed within the housing of the flux generator base unit, the signal being produced by the sensor in response to a magnetic field produced by a permanent magnet included with the receiving unit when the receiving coil is properly mated with the contactless mounting interface of the flux generating base unit.

55. The contactless battery charging and energy transfer apparatus of Claim 53, wherein the electric motor is energized in response to the signal produced by the sensor, so that the magnetic structure only rotates when the receiving coil is properly mated with the contactless mounting interface of the flux generating base unit.

56. The contactless battery charging and energy transfer apparatus of Claim 55, further comprising an indicator that indicates when the rechargeable storage battery connected to the output of the conditioning circuit is fully charged.

57. The contactless battery charging and energy transfer apparatus of Claim 55, wherein the conditioning circuit in the receiving unit detects when the rechargeable storage battery connected to the output of the conditioning circuit is fully charged and reduces the electrical current supplied to the rechargeable storage battery upon detecting such a condition.

58. The contactless battery charging and energy transfer apparatus of Claim 50, wherein the flux generator base unit comprises a sensor for determining when a battery connected to the output of the conditioning circuit is fully charged, and upon detecting such a condition, causes the electric motor to be de-energized.

59. The contactless battery charging and energy transfer apparatus of Claim 50, wherein the housing of the flux generator base unit is stepped, defining a plurality of cradles adapted to mate with respective main housings of receiving units of varying sizes.

60. The contactless battery charging and energy transfer apparatus of Claim 54, further comprising a motor control that supplies electrical current to the electrical motor and controls a rotational speed of the magnetic structure, said motor control monitoring the current supplied to the electrical motor.

61. A method for charging a battery by inductively coupling a varying magnetic field produced in a first portion of a base component to a receiver coil disposed in a first portion of a receiver component, without interfering with electronic components disposed in a second portion of the receiver component, comprising the steps of:

- (a) positioning the first portion of the receiver component proximate the first portion of the base component;
- (b) positioning the second portion of the receiver component proximate a second portion of the base component; such that the second portion of the base component substantially supports the second portion of the receiver component, and such that the first portion of the receiver component and the second portion of the receiver component do not substantially overlap;
- (c) generating a magnetic field with a permanent magnet disposed in the first portion of the base component;
- (d) coupling a driving force to an element in the base component so that the element is movable;
- (e) moving the element with the driving force to produce a varying magnetic field, the varying magnetic field being inductively coupled to the receiver coil disposed within the first portion of the receiver component and inducing a corresponding electrical current in the receiver coil;
- (f) conditioning the electrical current to produce a conditioned current at a voltage suitable for charging a battery; and
- (g) charging the battery with the conditioned current.

62. The method of Claim 61, wherein a source of the driving force is disposed remote from where the magnetic field is generated by the permanent magnet and is coupled to the element through a driven shaft.

63. The method of Claim 61, wherein the magnetic field is generated by a plurality of permanent magnets.

64. The method of Claim 61, wherein the element that is moved comprises said permanent magnet.

65. The method of Claim 64, wherein the step of moving the element comprises the step of rotating the permanent magnet to vary a magnetic flux produced by the permanent magnet along a path that includes the receiver coil.

66. The method of Claim 64, wherein the step of moving the element comprises the step of reciprocating the permanent magnet back and forth to vary a magnetic flux along a path that includes the receiver coil.

67. The method of Claim 61, further comprising the step of enhancing a magnetic flux linkage between magnetic poles of the permanent magnet and the receiver coil.

68. The method of Claim 67, wherein the step of enhancing the magnetic flux linkage comprises the step of providing a flux linkage bar for coupling a magnetic field from a pole of the permanent magnet into the receiver coil.

69. The method of Claim 61, further comprising the step of selectively varying a maximum magnetic field intensity coupled with the receiver coil.

70. The method of Claim 69, wherein the step of selectively varying the maximum magnetic field intensity comprises the step of varying a position of the permanent magnet relative to the receiver coil to control the magnetic field coupled to the receiver coil.

71. The method of Claim 69, wherein the step of selectively varying the maximum magnetic field intensity comprises the step of changing a speed with which the element moves.

72. The method of Claim 61, wherein the magnetic field is generated with a plurality of permanent magnets, and wherein the moving element comprises the plurality of permanent magnets, further comprising the step of moving one of the permanent magnets, and magnetically coupling another of the plurality of permanent magnets to the permanent magnet that is moved, so that another of the plurality of permanent magnets is moved thereby.

73. The method of Claim 61, wherein the magnetic field is generated with a plurality of permanent magnets that are fixed, and wherein the step of moving the element comprises the step of intermittently passing a flux shunt member adjacent to pole faces of the plurality of permanent magnets so as to provide a magnetic flux shunt path between the pole faces of the plurality of permanent magnets, to produce the varying magnetic field.

74. The method of Claim 73, wherein the plurality of permanent magnets are moved laterally back and forth past the receiver coil to vary the magnetic field.

75. The method of Claim 73, wherein the plurality of permanent magnets are radially movable on a support that is rotated to produce the varying magnetic field, further comprising the steps of:

- (a) forcing the plurality of permanent magnets toward each other when the support is at rest to reduce a startup torque required to begin rotating the support; and
- (b) adjusting a separation between the plurality of permanent magnets when the support is rotated, to change a magnitude of the magnetic field coupled to the receiver coil.

76. The method of Claim 69, wherein the step of selectively varying the maximum magnetic field intensity comprises the steps of:

- (a) providing a plurality of turns of a conductor wound around said permanent magnet; and
- (b) causing an electrical current to flow through the plurality of turns of the conductor to selectively adjust a maximum value of the magnetic field produced by said permanent magnet, said electrical current producing a magnetic field that either increases or reduces the magnetic field generated by the permanent magnet.

77. The method of Claim 61, further comprising the step of providing an indication of whether the battery is being charged by the conditioned current.

78. The method of Claim 61, further comprising the step of providing an indication of whether the battery is fully charged.

79. The method of Claim 61, wherein the first portion of the receiver component extends outwardly from the second portion of the receiver component.

80. The method of Claim 79, wherein the first portion of the receiver component comprises an antenna.

81. The method of Claim 65, wherein the receiver component comprises a portable device.